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UNIVERSITY OF ILLINOIS,

Agricultural Experiment Station.

CHAMPAIGN, FEBRUARY, 1893.

BULLETIN NO. 24.

VARIATIONS IN MILK.

This bulletin gives some results obtained from observations made with six cows during one period of lactation.

SUMMARY.

The butter fat was the most changeable constituent of the milk. The per cent of solids not fat was quite uniform. Both were higher in the last part of the period of lactation than in the first when the cows were fresh and the maximum quantity of milk was produced. This was especially true of the fat. As the activity of the milk glands gradually declines until the flow of milk ceases, the formation of the fat seems to hold out better than the other constituents of the milk.

Calculations of the total amount of milk and of butter fat were made from one, two, three, and four of the weights and tests of each month. The results so obtained were found to be in many cases 99, and in no case less than 90 per cent of the totals found by the daily weights and tests.

A gradual increase of the grain feed from 12 to 24 lb. a day per head and the change from stable to pasture feed each increased the yield of milk, but had very little if any effect on its quality.

OBJECT.

The object of this work was to get an exact record of the performance of different cows: To note what influence, if any, the changes in weather, season and feed actually had on these cows; their variation in live weight and in quantity of milk; the chemical composition of the milk in different parts of the period of lactation; how the composition was changed by any accidental or normal occurrence during the every day life of a cow for one year; the relative sensitiveness of different cows to the same cause or influence; to what extent the richness of milk was changed by a very large quantity of concentrated feed; and whether any or all the variations which might be noticed in the quantity and quality of the milk, applied to each of the cows included in this trial.

Conditions and Methods.

The experiment began July 6, 1891, and ended Oct. 14, 1892. Some experience in this line of work was obtained with other cows during the preceding months of May and June.

The shortest milking period of any of the cows was 278, the longest 428, days.

An analysis of the weighed milk of each cow was made nearly every day. This included an estimation of the per cent of solids and of butter fat in the daily milk, and of casein and fat in a week's composite sample.

None of the six cows was a superior representative of its breed. They were average animals, such as are the actual producers of the greater part of the country's milk supply.

Breed and Age of the Cows.

No.	Name.	Breed.	Average weight.	Age, years, July, 1891.	Date of last calf.	No. of days milk was tested
1	Jersey.....	Jersey	859	3	Sept.....	307
4	Jock.....	Holstein	1361	8	Jan.....	278
5	Med.....	Holstein	1054	8	Nov	322
3	Grace	Shorthorn...	1022	3	June.....	428
16	Duchess ..	Shorthorn...	1108	8	August...	332
18	Duchess ..	Shorthorn...	1174	7	August	342

The milking was done between the hours of five and six both night and morning. Each cow was not milked at exactly the same hour and minute every day, but the milking time was subject to such interruptions as are common in farm practice; hence there was observed no uniform difference in amount or richness between the night and morning milk of the cow whose milk of each milking was tested.

The cows were always tied up in the stable when milked. From May 1st to Nov. 1st they were either in the yard or pasture both day and night except at milking time. Beginning Nov. 1st the cows were stabled and only turned out into the yard a part of each day. This continued through the winter and spring until May 1st when pasture feeding began.

The weighing and testing of each cow's milk began about two weeks after calving.

A record was made of the pounds of milk given by each cow at each milking. The milk of cow No. 1 was sampled and tested after each milking.

A mixture of the morning and night milk of each of the other cows was tested every day. This gave a daily test of the milk from each of five cows, and of one cow's milk two tests each day.

The number of days in the year when the analyses of the different cows' milk were lost, is shown in the following table.

OMITTED ANALYSES.

Cow.	Number of determinations not made.		
	Of solids.	Of fat.	Of solids not fat.
No. 3	16	6	16
No. 4	7	3	8
No. 5	9	4	10
No. 16	11	2	11
No. 18	14	6	15
No. 1 a. m.	6	3	6
No. 1 p. m.	15	4	16

These missing tests were scattered throughout the year and were caused by some accident.

The cows were weighed every Monday at about 10 a. m.

The milking, weighing of the milk, and taking the samples for analysis were nearly all done by one man. He had some assistance at different times in the year.

The history of the cows' care and feed throughout the year was obtained from Mr. F. D. Gardner, assistant agriculturist of the Station.

The writer is responsible only for suggesting that an accurate record be kept, and, while the cows were stable-fed in the winter, that the grain should be gradually increased till the cows' daily ration was unusually large. From the figures thus obtained, the inferences in regard to the effect of the grain on the quantity and quality of the milk have been deduced as herein described.

All the samples of milk were brought to the laboratory and tested daily. Nearly all the analyses were made by Mr. Nelson, assistant chemist of the Station. This work amounted to something over 4,550 separate tests and analyses.

All the calculations necessary in making the tabular and other records contained in this bulletin have been made by two computers, in order to insure accuracy in the figures.

The tests made of each sample of milk included the per cent of butter fat, total solids, and solids not fat. The latter was calculated by difference.

A composite sample was collected from the milk of each cow. The per cent of casein and of butter fat was determined in each of these composite samples once a week, or after there was accumulated in them a mixture of samples taken from every milking for seven days. No preservative was added to these composite samples ; but powdered lye was used to thin the sour milk when it was tested. This operation was performed as described by the writer in bulletin No. 16, p. 510, of this Station.

TESTS OF THE COMPOSITE SAMPLES DURING THE YEAR.

The butter fat tests of the composite samples were compared with the average of the tests made of the milk each day during the time the composite samples were collected. This comparison was made with the milk of each cow every week during the entire year. This work gave an opportunity to re-

cord observations on the use of the method in all seasons of the year, and with the milk of different breeds of cows. It also gave experience in the manipulation. We have not found it necessary to change materially the method as originally described. It can be and is successfully used by creameries in paying patrons on the "test plan," and our year's experience has taught us that with a fair amount of care it is practically accurate.

An agreement of the test of the composite sample with the average test was most difficult to obtain with very rich milk. With such milk the composite sample test was often low. Milk of average composition (3.5 per cent fat) gave almost uniformly close agreement.

Methods used for Analyzing the Milk.

All the samples of milk were tested for butter fat by Dr. Babcock's method. The centrifugal machine used for making the separation of fat from the acid mixture was run by a one-horse power electric motor. [This is connected with the street electric railway of the city and makes a very convenient and useful laboratory power for grinding samples of feed. The speed is sufficiently uniform for testing milk.] During the first few months each sample of milk was tested for butter fat in duplicate ; later on the accuracy of each day's work was tested in the following way : A mixture was made of equal quantities of milk from all the samples tested at one time. A test of this mixed milk was compared with an average of the separate tests of the several samples used in making the mixture. If the two results agreed within one-tenth of one per cent, the work was not repeated. An examination was made of the correctness of the calibrations on each new test bottle used.

The per cent of total solids in each sample of milk was determined by drying in an oven surrounded by boiling water five grams of milk with about 25 grams of clean sea sand.

Feed of the Cows during the Year.

The cows were at pasture from May 1st to Nov. 1st. The pasture was mostly blue grass with some timothy and white clover. The severe drought in the summer of 1891 made the feed rather short, and from July 28th to Oct. 1st each cow was given 15 lb. green corn-fodder at milking time, or 30 lb. a day. Oct. 1st to 26th corn-fodder, with the largest ears picked out, was thrown into the pasture and 10 lb. broken corn with 5 lb. hay was fed at the stable daily. Oct. 26th 1 lb. oil meal was added to this ration. Nov. 1st the pasture feeding stopped and stable feeding began with a daily feed per head of 20 lb. broken ear corn, 10 lb. hay, and 2 lb. oil meal. Nov. 11th began feeding ensilage, gradually increasing the quantity to all that the cows would eat and decreasing the daily feed of broken corn. This was continued with 2 lb. oil meal and 6 to 10 lb. hay daily until Dec. 25th. The Shorthorn cows ate the ensilage with a relish; the one Jersey was more dainty at first but gradually developed an appetite for it.

Dec. 25th the cows were divided into two lots. Lot 1 contained cows No. 1, 3, and 5; lot 2 No. 4, 16, and 18. The object of this separation was to increase gradually the grain feed of lot 1, and note the effect on the milk. The feed of lot 2 continued unchanged until the supply of ensilage was exhausted, Jan. 1, 1892. Jan. 1st to March 1st the daily feed per cow was 20 lb. broken corn (equal to 16 lb. shelled corn), and 12 lb. hay. After Feb. 16th No. 16 and 18 were fed oat straw instead of hay. March 1st to April 8th the grain feed was changed to 20 lb. daily of a mixture made of two parts corn and cob meal, 1 part wheat bran, and 1 part oil meal. April 8th to 14th this feed was decreased by taking out the bran. April 14th the daily feed was changed to 6 lb. oil meal and 22 lb. hay. April 30th the cows were turned out to a good pasture and no other feed was given. The changes in the daily feed per head of the cows in lot 1 after Dec. 25th, are given on page 162.

The records of the daily weights and tests of the milk of each cow are not given here; but from them the results shown in the following tables have been calculated. These tables give the live weight of the cow each month. This is an average of the weights made every week. The average weight of milk given per day for every month, and the largest and smallest amount of milk produced on any one day of the month. The daily average per month and extremes in per cent of solids, butter fat, and solids not fat found in the milk; the average of the per cents of casein found in the four composite samples of milk collected every month and the pounds of solids, butter fat, and solids not fat calculated from those weights and analyses.

The summary at the foot of each table shows the total weight of milk, butter fat, and solids not fat produced by each cow during the period of lactation, and the average per day for the whole time. Also the extreme variations observed on any day during the experiment.

The daily average per cents of solids and butter fat are found by dividing the total weight of solids and of fat by the total weight of milk, and multiplying by 100.

The length of the period of lactation, or the number of days the cow was milked during the year, is given at the top of the tables.

Cow No. 1 — Jersey.—This cow was milked 307 days. She was nearly 4 years old when this record began, and her live weight has varied during this test from 745 to 962 lb. She gave 5,043 lb. milk, which contained 254 lb. butter fat, equal to 305 lb. of butter.

Weight of Milk.

The most milk given at any one milking was 14 lb.; the least, 1 lb. The most milk given on any one day was 25.5 lb., and the average per day for the whole time was 16.4 lb.

The table shows that at some one milking during a month the

Cow No. 1, Jersey. — The Daily Average and

Weighing and Testing the milk began Oct. 6,

Month.	Live wt.	Pounds of milk.						Per cent of solids.						Per	
		p m.		a.m.		Daily.		p.m.		a.m.		Daily.		p.m.	
		Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.
Oct. 6 to 31	851	10.6	12 8.5	12.3	14 10	22.9	25.5 18 5	14	14.8 13	13.7	14.7 12.4	13.8	14.6 13.1	4.8	6 4
November	797	8.3	9.5 6	10.7	12 9.5	19	21 16.5	14	15.5 11.9	13.8	15 5 12.7	13.9	14 9 13	4.9	6.5 2.9
December	771	7.5	9 3 5	9.5	11.5 8	17	20.5 12.5	13.8	16.2 12 6	13.8	15 2 13	13.8	15 13.1	4.9	7.3 3.3
January	769	8 6	9.2 7.5	11.1	12.5 10	19.7	21.5 17.7	14.4	18.6 12.8	14.4	20.2 13.6	14.4	17.5 13.4	5	9.4 3 9
February	827	8.7	10.5 7.5	10 6	11.7 9.2	19 3	20 7 17	14.3	19.2 13 5	14.3	16 6 13.3	14 3	16.7 13.6	4.7	10.2 4.1
March	856	8.7	9.5 7.2	8.8	9 5 8	17.5	18.5 15 7	14.5	16 13.9	14 7	15.5 14.1	14 6	15.4 14.1	5	6.2 4.5
April	864	8.1	10.2 6.2	7.7	10 5.2	15.8	20.2 11.4	14.8	16.6 13.2	15.2	16.7 14.1	15	16.6 14	5.4	7.1 4
May	890	8.4	9.7 7	7.6	9 5 6	16	18 13.5	15	17.1 13.6	15.3	16.9 13.8	15.1	16.7 14	5.1	5.9 4
June	927	6.4	7.2 5	6 3	7.5 5	12.8	14 2 10.7	15.3	16 8 14.3	15.5	16.9 14.2	15.4	16.3 14.5	5.6	7.1 4 6
July	947	3.8	5.7 1	4.2	7 1.5	8	12.2 3	16.8	20.1 13.7	16.7	22.4 14.2	16.8	19.4 14.8	6.3	9.7 3.3
Aug. 1 to 7	957	1 4	2 1	1 3	2 1	2 7	4 2	17.6	19.9 16.1	16.1	17.7 14 9	16.8	18 3 15.6	7.3	9.2 6.2
															For the
			12 1		14 1	16.4	25.5 2		20.1 11.9		22.4 12.4	14.4	19.4 13		10.2 2.9
Total					5043 9										

quantity of milk was considerably smaller or larger than usual; but the total milk of the different months was quite uniform. This cow was milked about 10 months, and during 9 months of this time her average daily milk decreased only from 23 to 13 lb., then in the last month she dried up very fast. This characteristic was not so marked with any of the other cows. She gave more milk at the morning than at the night milking for the first six months. During this time the morning milk was 1 to 4 lb. more than the night milk. There was no great difference either way in the amount of milk given at the two daily milkings in the last 4 months of her record. The night milk was 1 to 2 lb. greater during the first week the cow was at pasture; but for the remainder of the time very nearly the same quantity was given at both milkings. When a change in feed was made April 15th from 12 lb. corn and cob meal, 6 lb. oil meal, and 12 lb. hay to 6 lb. oil meal and 22 lb. hay, there was a sudden drop of 4 lb. in the amount of milk given, and this loss of milk continued till May 1st when pasture feeding began. Then the milk increased in quantity to about what it had been in the first part of April. There was a gradual decrease in the flow of milk from May

EXTREMES OBSERVED EACH MONTH FOR EACH MILKING.

1891, and continued to August 7, 1892—307 days.

cent of fat.				Per cent of solids not fat.						Per cent casein.			Solids, lb		Fat, lb.		S. not F.	
a m.		Daily.		p.m.		a.m.		Daily.					Daily.		Daily.		Daily.	
Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.	a m.	p.m.	Daily.	Av.	Extr.	Av.	Extr.	Av.	Extr.
4 3	5.2 3.4	4.5	5.2 3.9	9.2	9.8 8.1	9.4	9.6 8 9	9.3	9.8 8.6	3 32	3.29	3.3	3.21	3.64 2.42	1.05	1.27 .73	2.16	2.45 1.69
4.4	6.1 3.3	4.6	5.6 4.1	9.1	9.6 8.4	9.4	9.7 8.5	9 2	9.5 8.7	3.13	3.39	3.26	2.63	3.03 2.22	.88	1.07 .73	1 75	1.96 1.49
4 5	5.8 3.8	4.7	5 9 3.9	8.9	9.7 8.4	9.3	10.6 7.8	9.1	9.5 8 7	2.98	3 10	3.04	2.36	2.92 1.72	.8	1 .59	1.56	1.94 1.13
4.8	11.2 4	4.9	8 2 4 2	9.4	9.7 8.4	9.6	10 5 9	9.5	10 8.9	3.38	3.49	3.43	2.82	3 48 2.47	.97	1.31 .81	1.85	2 1.55
4.5	6 8 3.6	4 6	7.4 4	9.6	9.9 9	9.8	10.3 9.4	9.7	10 9.3	3.68	3.68	3.68	2.75	3.22 2.4	.88	1.4 .76	1.87	2.1 1.6
4.8	5.8 4.4	4 9	5.5 4.6	9.5	9.8 9.2	9 9	10.4 9.5	9 7	10 9.3	3 69	3.70	3.69	2.57	2.94 2.4	.86	.98 .81	1.71	2.06 1.53
5.4	6.9 4.5	5.4	7 4.4	9.4	10 2 7.6	9.8	10 2 9.4	9.6	10.1 9.1	3 54	3 51	3.52	2 36	2.87 1.86	.84	1.04 .7	1.52	1.9 1 11
5 4	7.2 4	5.2	6.1 4.3	9 9	10.9 9.3	9.9	10.4 9.3	9 9	10.4 9.4	4.06	4.10	4.08	2.56	2.81 2	.84	1.05 .66	1.72	1.86 1.3
5.8	7.5 4.7	5.7	6.7 5	9.7	10.2 8.7	9.7	10 4 9.3	9.7	10.2 9.3	4.10	4.11	4.1	2	2.18 1.69	.72	.89 .6	1.28	1 38 1.01
6 3	12.3 4.2	6.3	9.2 4.3	10.5	11.7 9 9	10.4	10.9 9.4	10 4	10.8 9.9	4.6	4.39	4.5	1.38	1.99 .49	.49	.76 .16	.89	1.27 .33
5.5	6.7 4.6	6.4	7.5 5.6	10.3	10.9 9.9	10.6	11 9.9	10.4	10.8 10	5.3	3.88	4.59	.45	.49 .33	.17	.25 .12	.27	.43 .21
whole period.																		
	12 3 3 3	5	9 2 3.9		11.7 7 6		11 7.8	9.4	10 8 8.6				2.37	3.64 .33	.82	1.4 .12	1.55	2.45 .21
													729.41		253.89		475.52	

1st to 31st, of about 2½ lb. per day. It changed very little in June; but fell off very rapidly in July till the first of August, when the cow was dry.

As a rule the weights of the morning milk only varied one-fourth to one lb. from that of the preceding morning. The greatest variation of this kind was three and one-half lb., which happened only once. This was also true of the night milking. A comparison of the two milkings on any one day shows that while they were generally about the same in quantity, there were times when one would be high and the other low. The greatest difference of this kind was 6 lb. This occurred in the two milkings of the day the cow was bred.

SOLIDS OF THE MILK.

The average per cent of solids in the 614 samples of milk of this cow for the whole period of lactation was 14.4, the highest 22.4, and the lowest 11.9, a difference of 9.5. The difference between the extreme per cents of solids in the daily milk, however, was 6.4, and between the daily average per month 3, showing that, although the

quality of the milk may take a sudden jump up or down at some particular milking, the change is not permanent.

There was only one sample of milk that showed 11.9 per cent solids; and but 9 out of the 614 that went below 13 per cent solids. A selection of the milks containing a high per cent of solids shows that four samples reached 20 per cent solids, but only one was 22 per cent, and that 26 samples were over 17 per cent of solids.

When the cow was fresh and gave the most milk, it contained the minimum amount of solids. The table shows that the milk gradually increased in richness of solids as the period of lactation advanced, until it reached the maximum, when the flow of milk was at its minimum, and the cow drying up. The per cent of solids went as low as 14.9 at one milking during the last week of the lactation period, and up to 19.9 a difference of 5; while in the first week there was a variation of only 2.3. This indicates that the milk of this cow was subject to quite extreme changes in quality, especially when the quantity was small. A comparison of the per cent of solids found in the morning milkings of each month, shows that with the exception of 3 months there was a difference of 1.8 to 3.8 per cent between the extremes. The greater differences observed in the 3 months were 5.6, 5.8, and 6.4. The variations of 5.6 and 5.8 per cent occurred six days apart, at the time when the heavy grain ration was begun. The difference of 6.4, between the highest and lowest of solids, was observed in the milk of the last month, when the cow was drying up. The night milkings showed similar variations. A study of the variations that occurred in the daily milk, or the sum of the analyses of the morning and night milk divided by two, shows a much smaller difference between extremes. When the heavy grain feeding was begun, there was a difference of 4.1 per cent solids between the extremes of that month, and of 4.6 in the last month of the period of lactation. With the exception of these two months there was a difference of only 1.3 to 3.1 between the highest and lowest daily per cent of solids every month. The variations occurred quite as often above as below the average, making the quality of the milk from one month to another about the same, except that it gradually increased in richness up to the end of the period of lactation. This is illustrated by the figures of the foregoing table and the diagram after page 152.

Butter Fat in the Milk.

The average per cent of fat in the milk of this cow was 5; the highest 12.3; the lowest 2.9 — a difference of 9.4. As has been stated before, the difference between the highest and lowest per cent of solids in the milk was 9.5, indicating that the fat is naturally the variable quantity in the solid matter of milk. The lowest per cent of fat, 2.9, was found in only one sample of milk, that of the morning of November 28th. Only 5 out of the 614 samples contained

less than 3.5 per cent fat. The samples of milk which contained the most fat were nearly all from the latter part of the period of lactation, only one sample reached 12 per cent fat, four were 10 per cent or over, and 25 were 7 per cent or over.

The table and the diagram show that during the first six months after calving the milk contained between 4 and 5 per cent of butter fat; after that time the average per cent was between 5 and 6. The difference between the highest and lowest per cent of fat in the morning milkings of the different months varied from 1.4 to 3.2, with the exception of two months, when the difference was 7.2 and 8.1. These were the same months when the greatest variation in solids was noticed. The night milk showed the same peculiarities, while, excepting these two months, the daily milk of each month showed a difference of only from .9 to 3 between the extreme per cents of fat observed in any one month. During the last two weeks of the period of lactation, when the cow gave only 2 to 5 lb. of milk daily, the per cent of fat was all the way from 6 to 9.4 and varied greatly from day to day. There were also several milkings at different times in the period of lactation when the milk contained 7, 9, 10 and 11 per cent of fat. At such times the amount of milk was neither very much above or below the average for that time. The per cent of fat in the morning milk was not greater or less than in the night milk for any great number of days. During short periods of 3 to 10 days in the year there would be a difference in the fat contents of the morning milk as compared with the night milk for the same time, but it soon changed and neither one was higher or lower than the other for more than 10 days at a time.

Solids not Fat.

These include the casein, milk sugar, and mineral substances of the milk. The average quantity contained in the milk of this cow was 9.4 per cent. The lowest per cent found in any sample of milk during the year was 7.6; the highest, 11.7—a difference of 4.1. Only 3 samples of this cow's milk went below 8 per cent of solids not fat and 24 above 10.5 per cent. The diagram and the figures in the table show that this constituent of the milk did not make such extreme variations as were observed in the butter fat. The per cent of solids not fat in the milk was very uniform throughout the whole period of lactation. It varied from 9 to 9.5 in the first three months, gradually rising to 9.5 to 10 during the next six months and was 10 to 10.5 the last month of the milking period. The per cent of solids not fat was generally .2 to .5 higher in the morning than in the night milk, except during the last two months of the period of lactation when there was no uniform difference either way.

Excepting a few times when analyses were lost, the milk of this cow was tested 307 days. As there were two milkings each day this made 614 samples. The average of all tests showed the milk to have

the following composition: solids, 14.4; fat, 5; solids not fat, 9.4 per cent. The highest and lowest percentages found in these samples were, solids, 11.9 to 22.4; fat, 2.9 to 12.3; solids not fat, 7.6 to 11.7.

The following table has been constructed from the record of all these samples to show that the extreme per cents were exceptional and that most of the milk was of a uniform quality. The table shows how many of the 614 samples of this one cow's milk were above 15 per cent and below 13.5 per cent solids; above 5.5 and below 4 per cent fat; above 10 and below 9 per cent solids not fat.

NUMBER OF SAMPLES OUT OF 614 IN WHICH PERCENTAGES OF SOLIDS, FAT, AND SOLIDS NOT FAT WERE ABOVE OR BELOW CERTAIN STANDARDS.

Per cent solids.	Per cent solids over 15 and under 13.5.			Per cent fat.	Per cent fat over 5.5 and under 4.			Per cent solids not fat.	Per cent. solids not fat over 10 and under 9.		
	a.m.	p.m.	*Daily av.		a.m.	p.m.	*Daily av.		a.m.	p.m.	*Daily av.
15–15.5	35	31	28	5.5–6	29	37	35	10–10.5	37	27	25
15.5–16	31	10	27	6–6.5	21	26	23	10.5–11	12	10	11
16–17	26	19	22	6.5–7.5	16	11	13	11–11.7	....	2	.....
17–18	6	4	9	7.5–9	3	9	4				
18–20	2	11	3	10–12	3	1	.....				
20	3	1	.....		....	....	.....				
Total.....	103	76	89		72	84	75		49	39	36
†Percentage of the whole.	30	25	29		23	27	24		16	12	11
13.5–13	19	9	14	4–3.5	13	2	2	9–8.5	3	30	11
13–12.5	4	4	.....	3.5–3	2	2	.....	8.5–8	....	5	.....
								8–7.5	1	2	.....
Total.....	23	13	14		15	4	2		4	37	11
†Percentage of the whole.	7	4	4		5	1	.....		1	12	4

*The daily average means here the per cent found each day by dividing by two the sum of the per cents found in the morning and night milk of each day.

†307 is taken for the whole number of samples in calculating this percentage.

A study of this table shows that the quality of the morning and night milk varied about the same. From one-fourth to one-third of all the samples contained over 15 per cent solids, but most of these were between 15 and 17; only very few went over 17 per cent, while 4 to 7 per cent of the whole number of samples went under 13.5 per cent, and a still less number under 13 per cent solids.

About one-fourth of all the samples had over 5.5, a very few were above 7, and only four had 10 to 12 per cent fat. There were only four samples below 3.5 per cent, and 17 out of the 614, between 3.5 to 4 per cent fat.

The limits of variation in the solids not fat are still narrower. Only two samples had over 11 per cent, and 3 under 8 per cent.

Cow No. 3 — Shorthorn.—The weighing and testing of this cow's milk was made every day for fourteen months. This unusually long period of lactation was due to her failure to get with calf. It makes her record all the more useful, as evidence of what the quality of milk is under these conditions, which occur more or less frequently among cows. She was four years old, and her live weight varied from 888 to 1,160 lb.

Weight of Milk.

The milk of this cow was weighed every milking, but the analyses were made on one daily sample, which was a mixture of equal parts of the morning and night milk. The total quantity of milk produced was 6,193 lb. This contained 228 lb. fat, equal to 274 lb. butter. The most milk given on any day was 26.5 lb. in July, the first

Cow No. 3, Shorthorn.—The daily Average and Extremes observed during each Month.

Weighing and Testing of Milk began July 6, 1891, and continued to September 4, 1892—428 days.

1891-92.	Live Wt.	Pounds. Milk.		Per cent. Solids.		Butter fat.		Solids not fat.		Casein	Pounds. Solids		Butter fat.		Not fat.
		Ave.	Extr.	Ave.	Extr.	Ave.	Extr.	Ave.	Extr.	Ave.	Ave.	Extr.	Ave.	Extr.	Ave.
July 6-31	993	24	26.5 20.5	12.2	13.4 11.7	3.7	4.4 2.7	8.5	10.3 8.5	3.23	2.93	3.56 2.45	.89	1.17 .62	2.04
August..	974	22.5	25 21	11.9	12.5 11.4	3.2	3.9 2.7	8.7	9 8	3.03	2.68	3.18 2.32	.72	.97 .57	1.96
Sept.....	957	17.8	22.5 12.5	12.1	13.3 11.4	3.3	4.2 2.8	8.8	9.1 8.4	3.05	2.15	2.78 1.45	.59	.85 .35	1.56
Oct.	958	13.9	16.5 11	12.9	14.5 12	3.7	4.4 2.9	9.2	10.4 8.5	3.33	1.79	2.09 1.3	.51	.66 .38	1.28
Nov.....	920	11.9	14 8.5	12.9	14.1 12	3.7	5 2.5	9.2	10.3 8.8	3.26	1.53	1.9 1.1	.44	.67 .29	1.09
Dec.....	920	12.1	16 10	12.8	14 10.8	3.8	4.9 3	9	9.6 7.2	2.92	1.55	2.11 1.33	.46	.6 .34	1.09
Jan.	927	16	17.7 14	13.1	14.2 12.5	3.7	4.6 2.7	9.4	10.2 9	3.34	2.10	2.41 1.84	.58	.76 .44	1.52
Feb. ...	1035	16.1	17.7 13.5	13 2	14.9 12.3	3.6	5.8 3 2	9.6	10 8.6	3.47	2.12	2.32 1 75	.58	84 .51	1.54
March..	1047	14.3	16 12.5	13.5	14.4 12.9	3.8	4.7 3.4	9.7	10.1 9.3	3.52	1.93	2.12 1.75	.54	.61 .5	1.39
April....	1054	13.8	16.5 11.5	13.5	15.1 12.7	4	5.8 3	9.5	10.5 9.1	3.49	1.86	2.13 1.59	.55	.72 .46	1.31
May.....	1079	14.5	17.2 10	13.3	14.3 12.8	3.8	4.6 3.4	9.5	9.9 8.9	3.89	1.93	2.31 1.39	.55	.7 .44	1.38
June....	1105	12.1	14 9.2	13.1	17.8 12.1	3.9	4.6 3.2	9.2	9.9 8.3	3.42	1.58	2 31 1.11	.47	.57 .35	1.11
July....	1118	9.3	12.2 6	13.3	16.2 12	4.2	6.2 2.8	9.1	11.1 7.4	3.8	1.24	1.62 .82	.39	.6 .27	.85
August..	1130	6.4	9.7 3.5	13.7	17 12.4	4.7	7.9 2.9	9	11.3 8.2	3.87	.87	1.4 .5	.3	.5 .16	.57
	For the whole period.														
		14.4	26.5 3.5	12.8	17.8 10.8	3.7	7.9 2.5	9.2	11.3 7.2		1.85	3.56 .5	.53	1.17 .16	1.32
Totals..		6193.3									794.37		227.8		566.57

month after calving. The preceding table shows that the milk decreased in quantity but little in August, the second month of the lactation period, but gradually diminished in the third and fourth months, till the fifth month, November, when she gave only about 12 pounds of milk daily. The quantity increased during the winter months of stable feeding, on a liberal grain ration, and it was not till the next July that the milk flow was so small as it had been in November. In August and September, the thirteenth and fourteenth months, the flow of milk diminished till the cow "went dry."

The average amount of milk given per day, for the whole period of lactation, was 14.4 lb., and for nine months of this time the daily average per month varied very little from this figure; for one month it was 2.5 lb. more, and another month 1.7 lb. less.

The minimum amount milk given in one day was 3.5 lb., and there were several days at the end of the milking period when she gave only four pounds.

No great variation was observed in the weight of milk produced from day to day in any month. There was a difference of 7 and 10 lb. between the highest and lowest daily milk of two months; but in the other twelve months this difference between extremes was from 3.5 to 6 lb. The daily milk was increased 6 lb. by a heavy grain ration in winter, and again by change from stable feeding to pasture.

Solids of the Milk.

The average per cent of solids in the 428 samples of this cow's milk was 12.8; highest, 17.8; lowest, 10.8—a difference of 7. The table shows that between the daily averages per month there was only a difference of 1.8 per cent of solids. There was only one sample that had 17.8 per cent of solids, and two that went as low as 10.8 per cent. Thirty-four samples were below 12 per cent (11.9 to 11.4); 28, above 14 per cent; but of these latter only 7 went above 15 per cent. There was a slight increase in the amount of solids in the milk from the first to the last part of the milking period; but the table shows that the per cent of solids was quite uniform through all the changes of feed and season in the 14 months of the trial.

Butter Fat in the Milk.

The average per cent was 3.7 in the milk of this cow; highest, 7.9; lowest, 2.5 per cent — a difference of 5.4. Only one sample went as low as 2.5 per cent, and 17 samples gave less than 3 per cent (2.7 to 2.9). One sample only reached 7.9 per cent; three, 6 to 7 per cent; sixteen, 5 to 6 per cent, and seventeen 4.5 to 5 per cent — making out of a total of 428 samples of milk from this cow 56 that were outside the limits of 3 to 4.5 per cent fat. As a rule the minimum per cent of fat was found in the milk when the cow was fresh, and gave the largest quantity, and the maximum per cent

of fat was during the last part of the milking period. The table shows, however, that there were days in the last month of the period of lactation when the milk contained only 2.9 per cent fat.

Solids not Fat.

The average per cent was 9.2; highest, 11.3; lowest, 7.2 per cent. With the exception of these two extremes, no sample went below 8 per cent, or above 10.5 per cent. There were only 10 other samples below 8.5 per cent, and seven above 10 per cent, making 410 out of the 428 samples that contained between 8.5 and 10 per cent of solids not fat. This illustrates what was also found true with cow No. 1, that the per cent of solids not fat is very uniform, and that the fat is the variable quantity in the milk solids.

The milk of this cow was quite uniform in quality throughout the whole milking period, and the sudden changes frequently observed in the milk of cow No. 1 did not occur.

Cows No. 16 and 18—Shorthorns, ages 8 and 7 years.—The tables show that these two cows were very much alike in the quantity

Cow No. 16, Shorthorn.—The daily Average and Extremes observed during each Month.

Weighing and Testing of Milk began August 31, 1891, and continued to July 27, 1892—332 days.

	Live Wt.	Pounds. Milk.		Per cent. Solids.		Butter fat.		Solids not fat.		Casein, av.	Pounds. Solids.		Butter fat.		Not fat.	
		Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr		Av.	Extr.	Av.	Extr.	Av.	Extr.
Sept..	1127	22.7	37.5 19	12.5	14 11.1	3.5	4.6 2.4	9	10.7 8.5	3.22	2.83	4.17 2.22	.79	1.03 .5	2.04	3.27 1.67
Oct....	1104	15.5	21.5 8	13.2	14.5 12.3	3.9	4.9 3.2	9.3	9.7 8.9	3.46	2.04	2.71 .84	.6	.8 .42	1.44	1.97 .32
Nov...	1068	12.9	16 9	13.5	15.8 12.5	4	5.8 3.2	9.5	10.3 8.9	3.65	1.74	2.15 1.19	.52	.85 .35	1.22	1.51 .84
Dec...	1041	11.9	13.5 11	13.3	14.5 12.2	3.9	5.2 3.4	9.4	10 8.8	3.33	1.58	1.88 1.43	.46	.67 .38	1.12	1.25 .97
Jan...	1036	12.2	14 11	13.2	13.9 12.6	3.9	4.5 3 4	9.3	9.8 9	3.34	1.61	1.84 1.44	.47	.56 .41	1.14	1.28 1
Feb ..	1057	10.3	13.5 7.5	13.5	14.4 12.5	3.9	5.4 3.3	9.6	9.6 8.9	3.2	1 39	1.77 .96	.4	.62 .25	.99	1.22 .71
March	1063	10.1	11.5 8	13.4	14.3 12.1	3.9	4.7 3.1	9.5	9.8 8.9	3.6	1.35	1.53 1.07	.39	.47 .33	.96	1.15 .74
April .	1095	9.3	13.2 6.2	13.9	15.6 12.5	4.1	5.3 2.9	9.8	10.6 9.1	3.63	1.29	1.69 .93	.38	.6 .28	.91	1.2 .64
May..	1176	5.9	8.5 2.2	14	19.4 11	4.1	9.2 1.8	9.9	10.2 9.2	4.2	.83	1.36 .34	.24	.36 .09	.59	.8 .16
June..	1195	6	7.5 5	13.4	14.6 12.5	3.9	4.6 3.5	9.5	10.6 8.9	4.05	.8	1.09 .67	.23	.34 .19	.57	.75 .47
July..	1236	6.1	9 5	13.7	14.7 11.7	4	4.8 1 9	9.7	10 3 8.9	4.45	.83	1.02 .54	.24	.36 .13	.59	.8 .18
		For the whole period.														
		11.2	37.5 2.2	13.3	19.4 11	3.9	9.2 1.8	9.4	10.7 8.5		1.49	4.17 .34	.44	1.03 .09	1.05	3.27 .16
Total.	...	3738.2		.....							495.62		145.8		349.82	

and quality of their milk; but quite different from the other four cows. They each gave something over 3,000 lb. of milk, and it contained, No. 16, 146 lb., and No. 18, 115 lb., butter fat. Previously to this year they had been used for raising calves, and consequently had been milked very little. This undoubtedly accounts for this poor record. The tables show that there was a great variation in the daily weight of milk given each month. This was particularly true when the cows were fresh in milk. During the first month after calving No. 16 varied from 25 to 10.5 lb., and No. 18 from 37.5 to 19 lb. milk per day. There were very unexcusable deviations in the milk all through the period of lactation. This was probably caused by their lack of training as milch cows. They often refused to give down their milk. The analyses show that their milk was of average quality. The per cents of solids and of fats varied more than in

Cow No. 18, Shorthorn.—The daily Average and Extremes observed during each Month.

Weighing and testing of milk began August 31, 1891, and continued to August 7, 1892—342 days.

Month.	Live Wt.	Pounds. Milk.		Per cent. Solids.		Butter fat.		Solids not fat.		Casein, av.	Pounds. Solids.		Butter fat.		Not fat.	
		Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.		Av.	Extr.	Av.	Extr.	Av.	Extr.
Sept..	1140	19.1	25 10.5	12.2	14.8 11.2	3.3	6.4 2.2	8.9	9.3 8.4	3.19	2 33	3.27 1.25	.63	1.41 .31	1.7	2.37 .94
Oct...	1123	13.3	17 8.5	12.8	14.7 10.2	3.6	5 2.6	9.2	10.8 8.7	3.45	1.7	2.27 1.1	.48	.66 .34	1.22	1.78 .76
Nov..	1114	10.5	16 6.5	13.1	15 12.1	3.8	5.4 2.7	9.3	10 8 6	3.43	1.37	2.15 .85	.40	.65 .23	.97	1.5 .62
Dec...	1131	9.2	13 4	13	15 11.8	3.7	5.5 2.6	9.3	10.8 8.2	3.15	1.19	1.78 .52	.34	.51 .14	.85	1.27 .38
Jan...	1130	9.1	11 7.7	13.5	14.5 12.6	4	4.8 3.3	9.5	10.1 9	3.34	1.23	1.47 1.06	.36	.45 .28	.87	1.05 .75
Feb...	1138	8.2	10 6.5	13.2	14.6 12.4	3.6	4.9 3	9.6	10 8.9	3.2	1.08	1.35 .85	.29	.39 .25	.79	.96 .59
March	1144	7.1	9 5.7	13.6	14.8 11.8	4	5.2 3.4	9.6	9.9 8.4	3.45	.96	1.26 .8	.28	.43 .24	.68	.85 .53
April .	1168	6.2	8.2 4.2	14.1	16.5 12.3	4.3	6.2 2.7	9.8	10.5 9.2	3.63	.87	1.09 .61	.26	.46 .14	.61	.79 .42
May..	1224	5.9	7.2 3	13.6	17.8 11.8	4	8.1 2.8	9.6	10 8.4	4.12	.8	1.06 .37	.24	.42 .1	.56	.78 .27
June..	1243	6 8	8.2 4.5	13	15.1 12.1	3.8	5.4 2.7	9.2	9.8 8.4	3.65	.89	1.05 .54	.26	.36 .14	.63	.77 .4
July ..	1270	3.8	6 1.2	13.5	15.3 12.2	4	5.6 2.8	9.5	11 8	4.19	.51	.86 .15	.15	.36 .04	.36	.6 .11
		For the whole period.														
		8.9	25 1.2	13.1	17.8 10.2	3.7	8.1 2.2	9.4	11 8		1.17	3.27 .15	.33	1.41 .04	.84	2.37 .11
Total.	....	3069.3		.....							399.8		115.3		284.5	

the milk of any of the other cows, except No. 1, whose milk was much richer.

The per cent of solids not fat in the milk of these cows, as in that of the others, was the most constant constituent of the milk, and the per cent of fat was the most variable.

Unlike the other cows' milk, that of these two did not increase in richness very much in the last part of the period of lactation. The erratic nature of these cows is illustrated by comparing the extremes observed in the first and last month of their milking period.

Cows No. 16 and No. 18.—Extremes in Milk Product of first and last Months.

Cow No. 16. First month.	Daily milk, lb.	Per cent		Cow No. 18. First month.	Daily milk, lb.	Per cent	
		Solids	Fat.			Solids.	Fat.
Highest.....	37.5	14	4.6	Highest.....	25	14.8	6.4
Lowest.....	19	11.1	2.4	Lowest.....	10.5	11.2	2.2
Last month.				Last month.			
Highest.....	9	14.7	4.8	Highest.....	6	15.3	5 6
Lowest.....	5	11.7	1 9	Lowest.....	1.2	12.2	2.8

The uncommon features illustrated in this table are several: First, that there should be such a variation in the daily weight and composition of milk in the first month of the milking period; second, that the per cent of fat should be so high in the first month when the average of the cow's milk was 3.5; third, that the quality of the milk in the two months should be so nearly the same; and fourth, that milk of such a low per cent of solids and fat should be produced in the last month of the period of lactation.

Several other very striking illustrations of great variations are shown in the following table:

Cows No. 16 and 18.—Some Extreme Variations in Milk Product.

Cow No. 16.	Milk, lb.	Per cent.			Cow No. 18.	Milk, lb.	Per cent.		
		Solids.	Fat.	Solids not fat			Solids.	Fat.	Solids not fat
Oct. 9	18.5	13.4	3.9	9.5	Sept. 17	17.5	11.4	2.7	8 7
10	6.5	12.9	3.6	9.3	18	10.5	11 9	3	8.9
11	8	12.4	3.2	9.2	19	22	14.8	6.4	8.4
12	16.5	12 4	3.4	9	20	16.5	12.3	3.6	8.7
13	17.5	13.3	4	9.3	21	19 5	11 7	2.8	8.9
April 30	8	14.2	4 2	10	April 30	6.5	13.7	4 2	9.5
May 1	8.5	13.7	4.3	9.4	May 1	5.7	13.2	3.9	9.3
2	4.5	12	2.6	9 4	2	4.2	11.8	3 4	8.4
3	5	11	1.8	9.2	3	5	12.3	2.8	9 5
4	4.2	12	2.5	9.5	4	3	12.6	3.2	9.4
5	3.2	12.7	3	9.7	5	3.5	13	3.6	9.4
6	7	19.4	9 2	10.2	6	5.2	17.8	8.1	9.7
7	2.2	15.4	5 6	9.8	7	3	13.6	4	9 6
8	6 5	14.5	4.6	9 9	8	4.5	13.1	3.4	9.7
9	6.5	14	4.2	9.8	9	7	14.2	4.5	9.7
10	6	14.3	4.4	9.9	10	5.5	13 6	3.8	9.8

Cow No. 16 had been giving from 16 to 18 lb. milk daily, and the sudden change to 6.5 and 8 lb. Oct. 10th and 11th, and then a return to her usual quantity without much change in the quality of the milk is a variation that the other cows did not show, except No. 18 which made nearly an equal variation in September. A sudden change from 10.5 to 22 lb. milk was recorded on Sept. 18th and 19th ; the quality of the milk changed also from 11.9 to 14.8 per cent solids and from 3 to 6.4 per cent fat. Afterward the amount and richness of the milk was about what it had been before this break and continued quite uniform.

When the cows were first turned out to pasture they were not fed grain at milking time, as had been the custom previously. The feed in the pasture was ample, and, with the exception of these two cows, the flow of milk suddenly increased in quantity. The lower part of the table shows how these two cows were affected by the change to pasture and absence of grain when milked. They gave less milk of poorer quality than before and continued to do so for a week with the exception of one day, May 6th, when both amount and richness, especially the latter, were very high. May 9th, 3 lb. bran was fed at milking time. This was continued and the milk returned to its usual record before pasture feeding began.

The complete record of the milk given by cow No. 16 during the whole period of lactation shows that the average composition of the 332 samples was solids, 13.3 per cent; fat, 3.9 per cent; solids not fat, 9.4 per cent. The per cent of solids was less than 12 in 12 samples, and only one went as low as 11 per cent. It was more than 14.5 in 20 samples and only once as high as 16 and 19.4 per cent. The per cent of fat was less than 3 in 12 samples and was less than 2.4 only twice. Eleven samples were over 5 and only one (9.2) was above 6 per cent fat. The per cent of solids not fat did not go below 8.5. It was above 10 per cent in 18 samples.

The average composition of the 342 samples of milk from cow No. 18 was solids 13.1; fat, 3.7; solids not fat, 9.4. Eleven samples went under 12 per cent, the lowest one was 10.2 per cent. 22 samples were over 14.5 per cent solids and only one (17.8) above 16.5 per cent. One sample contained 2 per cent fat, and 25 were between 2 and 3 per cent. One sample was above 6.4 per cent and 16 between 5 and 6.4 per cent. Eight samples contained less than 8.5 per cent, and 12 went over 10 per cent solids not fat.

Cows No. 4 and 5 Holstein. Each 9 years old March, 1892. The record of these two cows shows them to be producers of more but thinner milk than the other cows. No. 4 was a large cow and varied in weight from 1258 to 1457 lb. in the 278 days of her milking period. No. 5 varied less in live weight during her period of lactation than did any other cow, 1005 to 1094 lb. The record shows that the quantity of milk given by both cows did not decrease very much until the last two months. The most milk given on any one day by No. 4 was 37 lb.; No.

5, 34 lb. The daily average for the year was for No. 4, 21.7; No. 5, 22 lb. This is a larger quantity per day than any of the other cows gave. There were no sudden changes in the weights of the daily milk of No. 5, but No. 4 often varied 6 to 10 lb. from what she gave the day previous. This happened during pasture feeding but not before. The average per cent of solids in the milk of No. 4 was 11.9 and of fat, 3.3. This is lower than the standard for unadulterated milk which some state laws require. The table shows for the same cow that the per cent of both solids and fat increased in the last part of the period of lactation and in the last two months was over 12 per cent solids and 3.5 per cent fat. During the whole milking period of 278 days the per cent of solids went over 13 per cent on 29 days, but was over 14.7 only 3 days. It was 11 to 10 per cent 16 days and less than 10 only one day. The per cent fat went above 4.5 on 25 days, but was over 6 per cent only once. It was less than 3 per cent on 72 days but under 2 per cent only 4 days.

The per cent solids not fat was over 9 on 24 days and reached 10.9 but once. It was less than 8 per cent eight times, going once as low as 7.2 per cent.

Cow No. 4, Holstein.—The daily Average and Extremes observed during each Month.

Weighing and testing of milk began Jan. 13, 1892, and continued to Oct. 16, 1892—278 days.

Month.	Live Wt.	Pounds. Milk.		Per cent. Solids.		Butter fat.		Solids not fat.		Casein, av.	Pounds. Solids.		Butter fat.		Not fat.	
		Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.		Av.	Extr.	Av.	Extr.	Av.	Extr.
Jan...	....	29.6	34.7 27.5	11.9	12.6 10.8	2.9	3.6 2.5	9	9.2 8.3	2.93	3.53	4 3.11	.88	1.04 .68	2.65	2.84 2.4
Feb ..	1329	26.3	32.7 18	11.1	11.8 10.6	2.8	4.1 2.4	8.3	9 7.2	2.64	2.93	3 36 1.9	.75	1.04 .43	2.18	2 56 1.47
March	1303	26.1	29.5 20.7	11.8	12.7 11.1	3.2	4.2 2.8	8.7	8.8 8.2	2.81	3.08	3.55 2.31	.85	1.11 .62	2.23	2 65 1.69
April.	1286	26.5	33.5 20.2	11.9	13.2 10.4	3.2	4.5 2.7	8.7	9.7 7.8	2.85	3.16	4 2.5	.87	1.09 .63	2.29	3.32 1.59
May..	1379	29.7	37 20.7	12	15 10.6	3.1	4.7 2.2	8.9	10.9 8.2	3.14	3.57	5.09 2.46	.91	1.43 .63	2.66	3.57 1.8
June..	1448	24.7	35.2 13.2	11.9	16 10.1	3.4	6.6 1.6	8.5	9.4 7.8	3.22	2.96	4.29 1.36	.85	1.6 .25	2.11	2.99 .91
July ..	1417	18.6	27.7 10	12.1	14.1 10.6	3.6	5.6 2.4	8.5	9.1 7.9	3.45	2.25	3.54 1.21	.67	1.3 .32	1.58	2.42 .81
Aug ..	1370	14.6	20.2 9	12	14.2 10.7	3.7	5.4 2.2	8.3	8.8 7.9	3.63	1.76	2.61 1.2	.54	.96 .31	1.22	1.75 .74
Sept..	1471	10.8	17 4.7	12.4	14.7 9.1	3.8	5.8 1.5	8.6	9.7 7.6	3.69	1.34	2.09 .64	.41	.78 .23	.93	1.47 .41
Oct...	1493	5.1	7.7 1.7	13.3	17.1 10.5	4	5.3 1.7	9.3	10.6 8.4	4.11	.68	1.08 .29	.2	.33 .1	.48	.75 .26
		For the whole period.														
		21.7	37 1.7	11.9	17.1 9.1	3.3	6.6 1.5	8.6	10.9 7.2		2.58	4.29 .29	.71	1.6 .1		
Totals		6.032									718.28		198.2			

COW NO. 5, HOLSTEIN.—THE DAILY AVERAGE AND EXTREMES OBSERVED DURING EACH MONTH.

Weighing and testing of milk began Nov. 30, 1891, and continued to October 16, 1892—322 days.

Month.	Live Wt.	Pounds. Milk.		Per cent. Solids.		Butter fat.		Solids not fat.		Casein, av.	Pounds. Solids.		Butter fat.		Not fat.	
		Av.	Extr.	Av.	Extr.	Av.	Extr.	Av.	Extr.		Av.	Extr.	Av.	Extr.	Av.	Extr.
Dec..	1048	25.6	30 22.7	12.2	13.5 11.4	3 6	4.3 2.8	8.6	10.7 8.2	2.75	3.13	3.63 2.75	.92	1.11 .7	2.21	2.67 1.91
Jan...	1035	30	33.5 27.7	12.7	14.6 12	3.9	6.2 3	8.8	9.2 8.4	2.86	3.83	4.42 2.66	1.17	1.87 .97	2.86	3.01 1.36
Feb..	1082	30.4	34 27.2	12.5	13.7 11.8	3.5	4.8 3	9	9.3 8.6	2.9	3.8	4.52 3.52	1.08	1.58 .94	2.72	3.04 2.44
March	1080	26.9	30.2 24.5	12.5	13.7 11	3.6	4.4 2.6	8.9	9.5 8.5	2.88	3.37	3.73 2.91	.98	1.33 .69	2.39	3.55 2.19
April.	1049	23	29.7 17.2	12.6	16 11.7	3.5	4.5 2.9	9.1	11.5 8.7	3.01	2.91	3.47 2.27	.81	.99 .67	2.1	2.61 1.55
May..	1043	22.5	29.7 21	12.6	13.7 11.6	3.4	4 7 2.8	9.2	9.4 8.3	3.39	2.84	3.83 2.49	.78	1.13 .6	2.06	2.7 1.82
June..	1064	20.1	24.7 16.2	12.1	13.2 11.5	3.5	4.3 2.9	8.6	9.5 8.1	3.08	2.45	3.01 1.92	.72	.89 .61	1.73	2.12 1.02
July..	1067	20.1	23.5 18.2	12.1	12.7 11.6	3.6	3.9 3.3	8.5	9 7.8	3.05	2.45	2.89 2.13	.73	1.18 .43	1.72	2.05 1.36
Aug..	1036	16.5	20.7 12.5	12.5	13.6 12.2	3.8	4.8 3.3	8.7	9.3 7.9	3.1	2.07	3.1 1.64	.64	.83 .53	1.43	2.27 1 04
Sept..	1082	11.7	15.7 8.2	13.3	15.3 11.8	4.3	6.2 3.1	9	9.9 8.3	3.54	1.56	2 1.14	.51	.75 .34	1.05	1.41 .79
Oct...	1122	6.7	9.5 3	14	17.8 12.1	4.1	8 2.2	9.9	11.6 9 2	4.23	.94	1.3 .79	.28	.48 .13	.66	.9 .29
	For the whole period.															
		22	34 3	12.4	17.8 11	3.7	8 2.2	8.7	11.6 7.8		2.74	4.52 .79	.81	1.87 .13		
Totals		7,106.4									885.16		261.87			

The following table illustrates several of the sudden changes that occurred in the milk of this cow, both in amount and richness.

COW NO. 4. SOME VARIATIONS IN MILK PRODUCT.

	Milk, lb.	Per cent. Solids	Fat.	Solids not fat.		Milk, lb.	Per cent. Solids.	Fat.	Solids not fat.
May 9	27	11.8	3	8.8	June 16	25	11.4	3	8.4
10	24.7	12	3	9	17	16	10.1	1.6	8.5
11	34	15	4.2	10.8	18	15.7	11.3	3.3	8
12	28.7	11.2	2.5	8.7	19	17.2	13.4	5.1	8.3
13	24.5	13.7	4.7	9	20	13.2	10.3	1.9	8.4
14	31	11.4	2.8	8.6	21	17.7	12.4	3.8	8.6
June 1	32.7	12.3	3.6	8.7	July 16	13	14.1	5.6	8.5
2	29.2	12.3	3.6	8.7	17	27.5	11.4	3.2	8.2
3	19.2	11.7	2.9	8.8	18	23.2	14	5.6	8.4
4	33.5	12.5	3.6	8.9	19	14.5	10.6	2.4	8.2
29	28	11.6	2.8	8.8	Aug. 25	14.5	11.5	3	8.5
30	24.2	16	6.6	9.4	26	9	13.3	5.1	8.2
July 1	25.7	11 9	3.4	8.5	27	14	12	3.2	8.8

This table shows four or more distinct kinds of variations. The records of May 9th and 10th illustrate the course the milk had been taking for some time. May 11th there was an increase of 10 lb. in the milk and a considerable increase in its quality; May 12th both decreased; May 13th the pounds of milk descended, the quality ascended; May 14th the reverse was true; from June 1st to 4th there was a rising and falling in the quantity of milk of over 14 lb., but the quality remained nearly unchanged; June 30th the milk tested 6.6 per cent fat and the day before was 2.8 per cent, with a change of only 4 lb. in the quantity. These and the other groups of tests given in the above table show that with this cow there was no uniform relation between quantity and quality. A change in one was sometimes accompanied by similar variation in the other; and there were times when these deviations did not coincide. At other times one changed very noticeably and the other did not. The uniformity in the per cent of solids not fat, amidst all these changes, is very noticeable.

The record of cow No. 5 shows no such sudden changes as the above. The daily weights of milk varied only 3 lb. and the per cent of solids and fat were very uniform until the last month of the period of lactation, when there was an increase in quality.

The per cent of solids found during the 322 days was between 12 and 14, except on 17 days when it went above 14, but only twice above 15.6; and on 27 days, below 12 per cent solids, but never below 11 per cent. The average per cent of fat was 3.7, it ran up to 8 on one day only, and was above 4.5 per cent on 19 days; 2.2 per cent was the minimum which it reached once, and only 10 times in the year was it below 3 per cent. The per cent of solids not fat went above 9.5 on 14 days and below 8.5 on 28 days, although it was 8.4 on 13 of these 28 days.

The table on page 146 gives the number of samples of milk out of the total number tested for cow No. 1 that went above and below certain percentages of solids, fat, and solids not fat. The following table shows the same for the other 5 cows, except that the standards are lower.

It also shows that by far the greater number of samples containing over 14 per cent solids were between 14 and 14.5 per cent. Those under 12 per cent solids were mostly between 12 and 11.5 per cent. A very large proportion of those over 4.5 were between 4.5 and 5 per cent fat, and those under 3 were nearly all included between 3 and 2.5. The per cent solids not fat went a few times over 10 per cent, but hardly ever under 8 per cent.

Different standards were adopted for the milk of cow No. 1, and a summary of the variations in her milk is given on page 146.

NUMBER OF DAYS WHEN PERCENTAGES OF SOLIDS, FAT, AND SOLIDS NOT FAT WERE ABOVE OR BELOW CERTAIN STANDARDS.

Period of lactation.—Cow No. 3, 428 days; No. 16, 332; No. 18, 342; No. 4, 278; No. 5, 322.

Per cent solids.	Per cent solids over 14 and under 12.					Per cent fat.	Per cent fat over 4.5 and under 3.					Per cent solids not fat.	Per cent solids not fat over 9.5 and under 8.5.				
	No. 3	16	18	4	5		No. 3	16	18	4	5		No. 3	16	18	4	5
14–14.5	15	32	28	8	9	4.5–5	19	24	21	17	9	9.5–10	81	86	100	6	10
14.5–15	6	9	10	4	3	5–5.5	10	5	10	6	5	10–10.5	8	15	10	2	1
15–16	4	6	9	1	4	5.5–6	5	3	6	1	4	10.5–11	2	3	2	2	1
16–17	2	1	2	1	...	6–7	2	...	...	1	...	11–11.5	...	...	...	...	2
17–18	1	...	1	...	1	7–8	2	...	1	...	...	12	...	...	...	...	...
18–19	...	1	...	...	...	8–9	...	1	...	1	1	.....	...	...	...	...	...
Sum....	28	49	50	14	17		38	32	38	26	19		91	105	112	10	14
Per cent of whole No..	6.5	15	15	5	5		9	9	11	9	6		21	31	33	3	4
12–11.5	29	6	19	...	25	3–2.5	18	8	22	58	9	8.5–8	11	...	8	25	26
11.5–11	4	4	4	...	2	2.5–2	...	2	3	10	1	8–7.5	...	2	2	7	4
11.5–10	3	...	2	15	...	2–1.5	...	2	...	4	...	7.5–7	2	...	...	1	...
10–9.5	...	...	1	...	...	1.5–1	...	...	...	...	...	7	...	...	...	...	...
9.5–9	...	...	...	...	...	.....	...	...	...	...	...	.....	...	...	...	...	...
Sum....	37	10	26	15	27		18	12	25	72	10		13	2	10	33	30
Per cent of whole No..	9	3	7	5	8		4	3	7	26	3		3	6	3	12	9

TOTAL PRODUCTION OF THE COWS.

The following table shows the difference between the cows in total production and daily average during the year. The figures for milk, milk solids, and fat are found from the daily weights and analyses. The butter equivalent of the butter fat is found by multiplying the pounds of fat by 1.2, as recommended by Fleischman. (*Landw. Jahr., Band XX.*) The butter found by the use of this factor (1.2) contains 83.33 per cent fat. Such a calculation does not take into account the butter fat lost in creaming and churning the milk. Fleischman suggests that this loss is about 6 per cent of the total product.

DIFFERENCE IN TOTAL PRODUCTION AND DAILY AVERAGE COMPOSITION.

Cow No.	Ave. live wt., lb.	Milking period, days.	Total product, lb.				Average composition of milk.		
			Milk.	Solids.	Fat.	Butter.	Solids, per cent.	Fat, per cent.	Solids not fat, per cent.
1	859	307	5044	729	254	305	14.4	5	9.4
3	1022	428	6193	794	228	274	12.8	3.7	9.2
16	1108	332	3738	496	146	175	13.3	3.9	9.4
18	1174	342	3069	400	115	138	13.1	3.7	9.4
4	1361	278	6032	718	198	238	11.9	3.3	8.6
5	1054	322	7106	885	262	314	12.4	3.7	8.7

This table shows that the most milk was given by No. 5 and the least by No. 18. The richest milk throughout this entire period of

lactation was given by No. 1, the poorest by No. 4. The richest but not the most milk was given in this lot by the smallest and youngest cow. The most and nearly the thinnest, by one of the largest and oldest cows. These differences in size and in quantity and quality of the milk are characteristics of the two breeds to which these two cows belong; hence in this experiment it cannot be justly said that a small or young cow produces a small amount of rich milk, or that a large quantity of thin milk is a characteristic of an old or large cow. There may, however, be some relation between the age or size of the cow and the amount and richness of the milk she produces, dependent somewhat on the food she eats and assimilates.

The table also shows that one cow was milked only 278 days, and another 428 days; one weighed 859, and another 1361 lb. Calculating the record of each cow for a uniform length of time and live weight, as 300 days and 1,000 lb., gives the following results:

TOTAL PRODUCTION COMPARED WITH LIVE WEIGHT.

Cow No.	Age July, '91, years.	How many times the live weight.		Pounds per 1000 lb. live weight.					
				For whole time.		For 300 days.		Per day.	
		Milk.	Butter.	Milk.	Butter.	Milk.	Butter.	Milk.	Butter.
1	3	5.9	.35	5,870	355	5,739	345	19.13	1.15
3	3	6	.26	6,069	268	4,248	186	14.16	.62
16	8	3.4	.16	3,375	158	3,048	141	10.16	.47
18	7	2.6	.12	2,614	118	2,292	102	7.64	.34
4	8	4.4	.18	4,432	175	4,782	189	15.94	.63
5	8	7.7	.30	6,742	298	6,279	276	20.93	.92

The total amount of milk and butter produced per 1,000 lb. live weight is calculated by multiplying the yearly product by 1,000 and then dividing by the average live weight of the cow. This result divided by the number of days which the cow was milked gives the figures per day, and multiplying these by 300 shows the performance of each cow for the same live weight and length of milking period. When these cows are compared on this basis the figures for weight of milk produced, place them in the following order: No. 5 first, No. 1 second, No. 4 third, and then No. 3, 16, and 18. Comparing them as butter producers per 1,000 lb. live weight and 300 days milking period puts No. 1 in the front rank, No. 5 second, and the others in the following order: No. 4, No. 3, No. 16, and No. 18.

The difference in value to the owner of two cows like No. 1 and No. 18, whose feed was the same, which were milked the same length of time, and were of uniform weight, but produced 345 and 102 lb. butter respectively, teaches a lesson in profit and loss and shows what contrasts can be often found, probably, when cows' records are investigated by weights and tests.

The maximum and minimum figures for the year illustrate a possible error which might be made if it should so happen that an opinion of a cow's milk capacity was formed from one test only, if this test had

been made on the day when either one of the extreme results had been observed. The highest and lowest per cent of solids, fat, and solids not fat on any day during the whole period of lactation are as follows:

EXTREME VARIATIONS DURING PERIOD OF LACTATION—PER CENTS.

Cow No.	Total solids.		Butter fat.		Solids not fat.	
	Extremes.	Difference	Extremes.	Difference.	Extremes.	Difference.
1	11.9–22.4	9.5	2.9–12.3	9.4	7.6–11.7	4.1
3	10.8–17.8	7	2.5– 7.9	5.4	7.2–11.3	4.1
16	11–19.4	8.4	1.8– 9.2	7.4	8.5–10.7	2.2
18	10.2–17.8	7.6	2– 8.1	6.1	8–11	3
4	9 1–17.1	8	1.5– 6.6	5.1	7.2–10.9	3.7
5	11–17.8	6.8	2.2– 8	5.8	7.8–11.6	3.8

CALCULATED TOTAL PRODUCTION OF MILK AND BUTTER FAT.

The exact total production of milk and butter fat in the milk of each cow was found from the sum of the numbers obtained by the daily weights and tests.

These records furnish the data for calculating the total production of each cow from weights and tests made only one, two, three, or four times each month and for comparing the yearly amount thus obtained with that found from the daily weights and tests.

The accuracy of such a computation depends a great deal on the cow. If the flow of milk decreases gradually from the time the cow is fresh until she is dry, and there are no sudden fluctuations in the quality from day to day, her total production for the whole period of lactation can be quite accurately calculated from comparatively few weights and tests. A cow that does not give milk of uniform quantity or quality, but varies more or less from day to day, requires a greater number of weights and tests of her milk to make such a calculated product agree with that found from daily weights and tests.

The records of the six cows used in this experiment show quite a difference in milk production. They differ not only in the total production but in the relative amount of the total which is produced in the different parts of the milking period. Some gave the most milk when they were fresh, but others reached their maximum a few months after calving. This increase in quantity of milk was caused by the feed. A cow calving in January gave more milk the following May on pasture feed. This may not be true of all cows, but it was observed with one of these. These changes in the periods of lactation, and the daily variations peculiar to each cow explain the variety of deviations from the total production found when the total production of these cows was calculated from the same number of weights and tests.

The method used for calculating the total production was as follows: Multiply the average per day of all the test days by the total number of days each cow was milked. If a cow was milked 300 days and the milk weighed and tested once every 30 days, there were 10 test

days. The average weight of milk and butter fat found per day from these 10 test days multiplied by 300 gave the calculated total product. If the milk was weighed and tested once in 15, 10 or 7 days there were 20, 30, or 43 test days, from which the daily average was obtained and multiplied by 300 in each case.

The following table illustrates the details of a calculation of the total milk product of cow No. 1, found from tests made once in 30 days.

METHOD OF CALCULATING MILK PRODUCT FROM TESTS EVERY 30 DAYS.

Milking period Oct. 6, 1891, to August 8, 1892.—307 days.

Test day.	Pounds, milk.	Per cent.		Pounds.	
		Solids.	Fat.	Solids	Fat.
November 4....	20.5	13.5	4.7	2.76	.96
December 4....	18.7	13.8	4.6	2.58	.86
January 3.....	17.7	14.2	4.9	2.51	.86
February 2.....	20	14.1	4.5	2.82	.90
March 3.....	18.2	14.4	4.7	2.62	.86
April 2.....	19.5	14.2	4.4	2.63	.81
May 2.....	17.7	14.5	4.8	2.57	.85
June 1.....	13	15.8	5.5	2.05	.72
July 1.....	12.2	16.3	6.2	1.99	.76
July 31	3.2	18.1	7.2	.58	.23
Total.....	159.7	.....	.....	23.11	7.81
Average.....	15.97	.....	.....	2.31	.78
Average x 307, total for year.	4.903	.....	.....	709	240

The other calculations are made in the same way from weights and tests made once in 15, 10, and 7 days.

The results of an application of this method of calculation to the records of each cow, are given in the following tables. They show how near to the sum of all the daily weights and tests computed weights and tests can be obtained by making weights and tests once in 30, 15, 10 or 7 days, and what percentage of the whole the computed weights represent.

TOTAL PRODUCTION OF MILK AND BUTTER FAT CALCULATED FROM WEIGHTS AND TESTS MADE 1, 2, 3, AND 4 DAYS EACH MONTH.

	Milk.					Butter fat.				
Days between tests....	30	15	10	7	Daily.	30	15	10	7	Daily
Cow No. 1.										
Total pounds.....	4903	4970	5105	4973	5044	240	240	256	246	254
Varies from daily lb...	141	74	61	71	0	14	0	2	8	0
Per cent of daily.....	97.2	98.5	101	98.6	100	94.5	90.9	100.8	96.9	100
No. of weights and tests	10	20	30	44	307	10	20	30	44	307
Cow No. 3.										
Total pounds.....	6020	6076	6191	6121	6193	224	223	229	234	228
Varies from daily lb...	173	117	2	72	0	4	5	1	6	0
Per cent of daily.....	97.2	98.1	100	98.8	100	98.3	97.8	100.4	102.6	100
No. of weights and tests	14	28	42	61	428	14	28	42	61	428
Cow No. 4.										
Total pounds.....	6075	5900	5862	6004	6032	202	189	189	189	198
Varies from daily lb...	43	132	170	28	0	4	9	9	9	0
Per cent of daily.....	100.7	97.8	97.2	99.5	100	102	95.4	95.4	95.4	100
No. of weights and tests	9	18	27	40	278	9	18	27	40	278
Cow No. 5.										
Total pounds.....	7232	7181	7084	6955	7106	273	266	264	261	262
Varies from daily lb...	126	75	22	151	0	11	4	2	1	0
Per cent of daily.....	102	101	99.6	98	100	104	101.5	100.8	99.6	100
No. of weights and tests	10	21	32	46	322	10	21	32	46	322
Cow No. 16.										
Total pounds.....	3396	3619	3559	3635	3738	136	148	152	145	146
Varies from daily lb...	342	119	179	103	0	10	2	6	1	0
Per cent of daily.....	90.8	96.8	95.1	97.2	100	93.2	101.4	104	99.3	100
No. of weights and tests	11	22	33	47	332	11	22	33	47	332
Cow No. 18.										
Total pounds.....	2770	3037	2896	2948	3069	103	113	109	109	115
Varies from daily lb...	299	32	173	121	0	12	2	6	6	0
Per cent of daily.....	90.3	93.4	94.4	96.1	100	89.6	98.2	94.8	94.8	100
No. of weights and tests	11	22	34	49	342	11	22	34	49	342

CALCULATIONS FOR TOTAL WEIGHTS OF MILK AND BUTTER FAT COMPARED WITH DAILY WEIGHTS AND TESTS.

Cow	No. 1.	No. 3.	No. 4.	No. 5.	No. 16.	No. 18.	Average.	Deviation from 100.
	Weights of milk, percentages.							
Weighing daily.....	100	100	100	100	100	100	100	.....
Once in 7 days.....	98.6	98.8	99.5	98	97.2	96.1	98	-2
Once in 10 days.....	101	100	97.2	99.6	95.1	94.4	98	-2
Once in 15 days.....	98.5	98.1	97.8	101	96.8	93.4	97.6	-2.4
Once in 30 days....	97.2	97.2	100.7	102	90.8	90.3	96.4	-3.6
	Weights of butter fat, percentages.							
Testing daily.....	100	100	100	100	100	100	100	.....
Once in 7 days.....	96.9	102.6	95.4	99.6	99.3	94.8	98	-2
Once in 10 days.....	100.8	100.4	95.4	100.8	104	94.8	99 4	- .6
Once in 15 days.....	96.9	97.8	95.4	101.5	98.2	98 2	98.5	-1.5
Once in 30 days.....	94.5	98.3	102	104	93.2	89.6	97	-3

A summary of these results, given in the last table, shows what percentages of total production were found when one to four weights and tests per month were made of the milk of these cows.

The summary tables show that for calculating the total weight of

milk produced by all these cows, weighing the milk once in seven days, gave nearest to the total amount found by daily weighings. This was not true of every cow, as the table shows that with two cows weighing the milk once in 10 days gave a total nearer that found by the daily weighings. The records of all the cows show that the difference between the extreme percentages of the whole amount was least by weekly weighings, and greatest when the milk was weighed once in 30 days.

Weighing milk once in	7 days.	10 days.	15 days.	30 days.
Highest percentage	99.5	101	101	102
Lowest percentage	96.1	94.4	93.4	90.3
Difference	3.4	6.6	7.6	11.2

The table also illustrates the variety of results that are obtained by applying this method of calculation to different cows. No. 16 and 18 were very irregular in the quantity of milk given from day to day. Weighing their milk weekly gave only 96 to 97 per cent of the total found by daily weighings, while so small a percentage of the whole was only found with the other cows when their milk was weighed once in 30 days.

The results from these six cows show that calculations of the total weight of milk produced in one period of lactation gave from 96.1 to 99.5, average 98, per cent of the total quantity, when the milk was weighed on one day of each week; 101 to 91.4, average 98, per cent, when weighed once in 10 days; 101 to 93.4, average 97.6, per cent, when weighed once in 15 days; and 102 to 90.3, average 96.4, per cent, when weighed once in 30 days.

These same observations apply to the calculation of the total production of butter fat.

Testing the milk once in	7 days.	10 days.	15 days.	30 days.
Highest percentage	102.6	104	101.4	104
Lowest percentage	94.8	94.8	95.4	89.6
Difference	7.8	9.2	6	15.4
Average of the six cows.	98	99.4	98.5	97

The average of all the results shows that weighing and testing the milk every seventh day gave with these six cows 98 per cent of the total milk, and 98 per cent of the total butter fat; 98 per cent of the milk, and 99.4 per cent of the butter fat, when weighed and tested every tenth day; 97.6 per cent of the milk and 98.5 per cent of the butter fat, when weighed and tested every fifteenth day; 96.4 per cent of the milk and 97 per cent of the butter fat, when weighed and tested every thirtieth day.

Does an Increase in the Grain Ration fed to Cows influence the Richness of the Milk?

This question has been often discussed and among the many opinions that are expressed two at least seldom fail to be given: First, that

rich feed makes rich milk, and second, that the milk may be increased in quantity but not in quality. These statements are supposed to apply to the milk of one cow during one period of lactation. It is obvious that a certain amount of food is necessary to keep a cow in such condition that she neither gains nor loses weight. This maintenance ration is a variable quantity differing with cows of various sizes. It is greater for a cow weighing 1200 lb. than for an 800-pound cow. The disposal that is made of any excess of food over maintenance probably depends on the natural capacity of the cow. One may convert the excess into live weight; another will show an increase in milk; and it is probable that others gain neither in weight nor milk, the excess of feed passing them unassimilated.

Without further discussing the question or expressing an opinion, the following evidence in the shape of weights and analyses of feed and milk has been obtained from the daily records of three cows, No. 1, 3, and 5. The history of the cows and of their care and feed up to Dec. 25th has already been given on p. 140. The changes in the daily feed per head of these cows after Dec. 25th are shown in the following table:

FEEDING PERIODS; MATERIALS FED, AND WEIGHTS OF EACH IN POUNDS.

	Feeding Period.	Corn and cob meal.	Wheat bran.	Oil meal	Timothy hay	Corn ensilage
1	Dec. 1–Dec. 25	—	—	2	10	20
2	" 25–Jan. 6	6	4	2	6	20
3	Jan. 6–Feb. 2	8	4	4	12	—
4	Feb. 2– " 17	10	5	5	12	—
5	" 17–Apr. 8	12	6	6	12	—
6	Apr. 8– " 14	12	—	6	12	—
7	" 14– " 30	—	—	6	22	—
8	" 30–Sept. 1	pasture only.				

The cows had access to a straw stack when in the yard during the winter; but as this was only a short time each day, and as their grain ration was heavy, there probably was little straw eaten by these cows after the first feeding period.

This course of feeding was tried for the purpose of increasing the richness of the milk if such a thing were possible. The table shows that the total grain feed per day and head was gradually increased from 12 to 24 lb. and the latter quantity, which was a high feed for these cows, was continued for two months. The change from a grain feed of 24 lb. to pasture feed and no grain was made gradually, as the table shows.

A chemical analysis was made of these feeding stuffs and, by the use of the digestion coefficients published by Professor Jordan, a calculation shows that 100 lb. of each feed contains pounds of digestible nutrients as follows:

Pounds Digestible Nutrients in 100 Pounds Feed.

	Corn and cob meal.	Wheat bran.	Oil meal	Timothy hay.	Ensilage.	Oat straw.
Organic matter.....	66.7	54.2	65.6	49.8	24.5	43.6
Protein.....	7	12.9	25.6	3.1	1.6	1.4
Crude fiber.....	2	3.2	3.5	17	4.9	21.8
Nitrogen free extract...	54.7	34.5	27.5	28.2	17.1	19.4
Fat (ether extract).....	3	3.6	9	1.5	0.9	1
Total dry matter not the digestible.....	86.3	89.7	87.6	91	38.6	90.4

An exact record of the weight of feed each cow had before Dec. 25th the writer was not able to obtain, as the ensilage or straw was not weighed; but assuming that the cows each ate 20 lb. of ensilage daily with 10 lb. of hay and 2 lb. of oil meal, the digestible nutrients consumed per day and head are given in the following table. Each period includes the time a ration was fed without change.

The live weight of cows No. 3 and 5 was between 1,000 and 1,100. No. 5 did not gain much during this course of feeding. No. 3 increased in weight from 912 lb. to 1097 lb. No. 1, from 800 lb. to 900 lb.

The figures of the table (page 164) show the digestible nutrients for very nearly 1,000 lb. live weight with No. 3 and 5, but for cow No. 1 they would be somewhat larger as her average weight was about 850 lb.

The table also gives the average daily yield of milk and its composition during each feeding period.

The feeding stuffs that are consumed by cows contain some water, which is sufficient in many to make them juicy, while in others it is only perceptible by the loss in weight that occurs when they are heated at such a temperature that none of the vegetable matter is volatilized. The dry matter is the water free substance of the feed. A certain part of the dry matter is digestible. The rest passes the animal undigested. Both may contain the same constituents but the digestible portion is of greater interest to feeders.

A chemical analysis of a feeding stuff shows approximately the different groups of substances contained therein. Protein is the name given to that group which contains nitrogen in addition to the carbon, hydrogen and oxygen. This nitrogenous part is the "hearty" portion of the feed, the "flesh former," that group which beans contain in a large quantity and is nearly lacking in rice; or among cattle foods a large amount of protein is found in cotton seed meal and very little in wheat straw. The carbohydrates include the starch, sugars, and cellulose, and with the fats make what is often called the "heat forming" part of the feed. The nutritive ratio shows how many times the "heat formers" are greater than the "flesh forming" part of the feed; or the proportion of protein to the sum of the carbohydrates and fats. The method of calculating the potential energy and nutritive ratio is given by the writer in bulletin No. 9, p. 319, of this Station. The organic matter represents the sum of the protein, carbohydrates and fats. The standard feed given in the table represents what is called a sufficient and

Nutrients consumed and Milk Yield during the several feeding Periods.

	Feeding periods, 1891-2.	Nutrients consumed daily per head.						Amount and quality of milk produced.									
			Digestible.				Nutritive ratio	Cow No. 1.			Cow No. 3.			Cow No. 5.			
		Dry matter, lb.	Organic matter, lb.	Protein, lb.	Carbohydrates, lb.	Fats, lb.	Potential energy, calories.		Daily yield, lb.	Composition. Solids, %	Fat, %	Daily yield, lb.	Composition. Solids, %	Fat, %	Daily yield, lb.	Composition. Solids, %	Fat, %
1	25 days to Dec. 25.	18.58	11.18	1.13	9.54	.51	22001	1:9.4	16.7	13.89	4.64	11.5	12.73	3.81	25.1	12.32	3.58
2	12 days to Jan. 6 ..	23.72	15 34	1.94	12.63	.77	30348	1:7.4	18.4	14.44	5.24	14.8	13.14	3.76	29	12.43	3.88
3	27 days to Feb. 2..	24.91	16 07	2.45	12.7	.92	32071	1:6	19.9	14.25	4.91	16.3	13.1	3.57	31.1	12.3	3.71
4	15 days to Feb. 17.	28.41	18.65	2.98	14.51	1.16	37211	1:5.7	19.5	14.18	4.48	16.6	13.21	3.54	30.7	12.47	3.55
5	51 days to April 8..	31.9	21.13	3.5	16.34	1.29	42393	1:5.5	17.6	14.5	4.81	14.9	13.36	3.79	27.8	12.43	3.54
6	6 days to April 14..	26.5	17.89	2.73	14.08	1.08	35825	1:6	18.6	14.45	5	15.2	13.12	3.7	26.2	12.1	3.39
7	16 days to April 30.	25.25	14 88	2.21	11.8	.87	29729	1:6	13.6	15.6	5.97	12.5	13.71	4.27	19.4	13.14	4.02
8	31 days to June 1..	Luxuriant blue grass pasture.						1:4	16	15.1	5.2	14.5	13.79	3.66	22.5	12.6	3.4
Standard.....		24	15.5	2.5	12.5	0.5	28000	1:5.5									

well balanced ration for a milch cow—the nutrients consumed per day and per 1,000 lb. live weight.

Table on this page shows that during period 1 the feed of these cows was considerably below the standard, in everything except fats. Period 2 the protein was low. Period 3 the feed was very near the standard, except the fat, which was high. The maximum feed was reached in period 5, which was 51 days long. During this time the feed eaten by each cow daily was about 8 lb., or 33 per cent, above the standard in dry matter; 1 lb., or 40 per cent, above in protein, and .79 lb., or 158 per cent, above in fats. No bad effect was noticed from the 6 lb. of oil meal fed daily in this, or the following two periods, when the feed was gradually decreased until period 7. The 6 lb. oil meal and 22 lb. hay fed in period 7 reduced the ration to very near the standard, except that it was a little low in carbohydrates.

The nutritive ratio was somewhat narrowed from the first period.

When the cows were turned out to pasture no grain was fed. The grass in the pasture was excellent feed; but the month of May was very cold and rainy. This probably had an influence on the flow of milk.

The part of the table giving the weight and composition of the milk shows the average per day calculated from daily weights and tests during each period. The milk of each cow increased in quantity from periods 1 to 3. This increase amounted to 3 lb.

per day for No. 1; 5 lb. for No. 3; and 6 lb. for No. 5. The average per cent of solids was greater in period 2 than in 1 in the milk of No. 1 and 3, and but very little different in that of No. 5. The per cent of fat increased in the milk of No. 1 and 5, but decreased in that of No. 3 during period 2. After this time no great change in quantity or quality is noticeable in the milk of any of the cows until period 7. There was a slight decrease in the daily pounds of milk during the 111 days, between Dec. 25th and April 14th. This represents about one-third of the period of lactation, and it is probable that there would have been a much greater decrease if the feed had been less. The table shows that the quality of the milk did not increase by this long period of feeding which kept the quantity from decreasing, as it would naturally have done, with the progress of the lactation period. There is very little difference in the per cent of solids and of fat in the milk of the second and sixth periods, although during the intervening periods a ration very rich, in both protein and fat, had been fed for 93 days.

The record of each cow shows the same changes in the milk in periods 7 and 8. The nutrients in the daily feed were reduced nearly to the standard in period 7. The daily milk yield of the different cows decreased from 3 to 7 lb.; but the richness of the milk increased in every case. This amounted to about one per cent gain in both solids and fat in the milk of No. 1, and .5 per cent to one per cent in that of No. 3 and 5. The difference in feed was a substitution of 10 lb. hay for 12 lb. corn and cob meal. This made a reduction of 1.5 lb. dry matter, .5 lb. protein, and .21 lb. fats in the daily ration per head, and a difference in the coarseness of the feed represented by a change from 18 lb. grain, with 12 lb. hay to 6 lb. grain, with 22 lb. hay. This ration was fed only 16 days, and the indications are that if continued the cows would have soon gone dry in milk. When pasture feeding began there was an increase in the yield of milk from each cow. The quality of the milk decreased from what it had been during the 16 days of period 7, which immediately preceded; but the per cent of solids and of fat in the milk was about the same in the month of May on pasture feed, as it had been during the winter, when the cows were stable fed on a grain ration.

The table gives the average per cent of solids and fat in the milk produced during each of the periods, which were from 6 to 51 days in length. Such an average does not show the extremes that may occur in the amount and richness of the daily milk. The inequalities of quantity and quality from day to day are covered up by taking the mean production for a number of days. Twice in the period of lactation of these cows quite a sudden change was made in the flow of milk: first when the grain feed was increased during the winter stable feed-

ing, and second when the cows were turned out to pasture in the spring.

The four following diagrams on pp. 167–170 show these changes as they occurred in the weight and composition of the milk from day to day. The first two and the fourth plates give the daily record of cows No. 1, 3, and 5 for a few days before and about 30 days after the grain ration was increased as indicated in the table. The third plate gives the record of cow No. 3 for a short time before and after pasture feeding began. Each diagram shows the record of one cow for 40 days, which are designated by a date every fifth day at the top of the diagram. The cows were weighed once a week and the live weight and date of weighing are indicated by the point where the dotted and solid part of the "weight of cow" line changes. The heaviest broken line on all the plates indicates pounds of milk, and this is numbered on the left hand margin of the record of cow No. 1, but by figures enclosed by a circle on the other plates.

The diagram for cow No. 1 shows the per cent of solids between the 13 and 14 per cent lines, per cent of fat between the 4 and 5 per cent lines, per cent of solids not fat between the 9 and 10 per cent lines, pounds of solids between the 2 and 3 pound lines, pounds of fat between the 0 and 1 pound lines, and pounds of solids not fat between the 1 and 2 pound lines. These percentages and pounds are indicated in the other three plates by the brackets and figures on the two sides of each diagram.

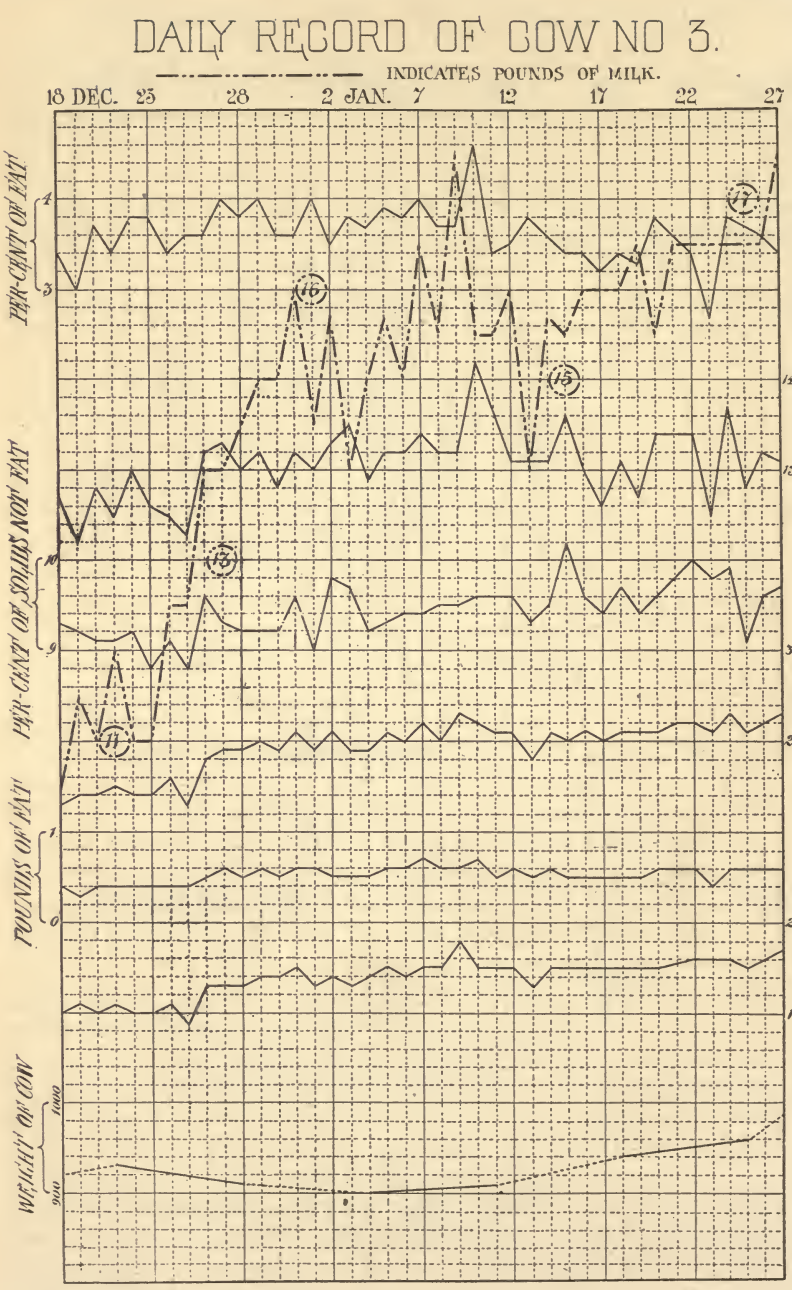
The grain ration was increased Dec. 25th and the change from stable to pasture made April 30th. All the records show that the increase of feed was accompanied by a considerable increase in the pounds of milk produced and consequently in the pounds of solids, fat, and solids not fat in the milk; but with the exception of one or two days, there were no greater changes in the percentages of fat in the milk after the increase of feed than before it was made. There was, however, a slight increase in the per cent of solids not fat in the milk of all the cows during the latter part of January, when the increased grain ration had been fed about a month.

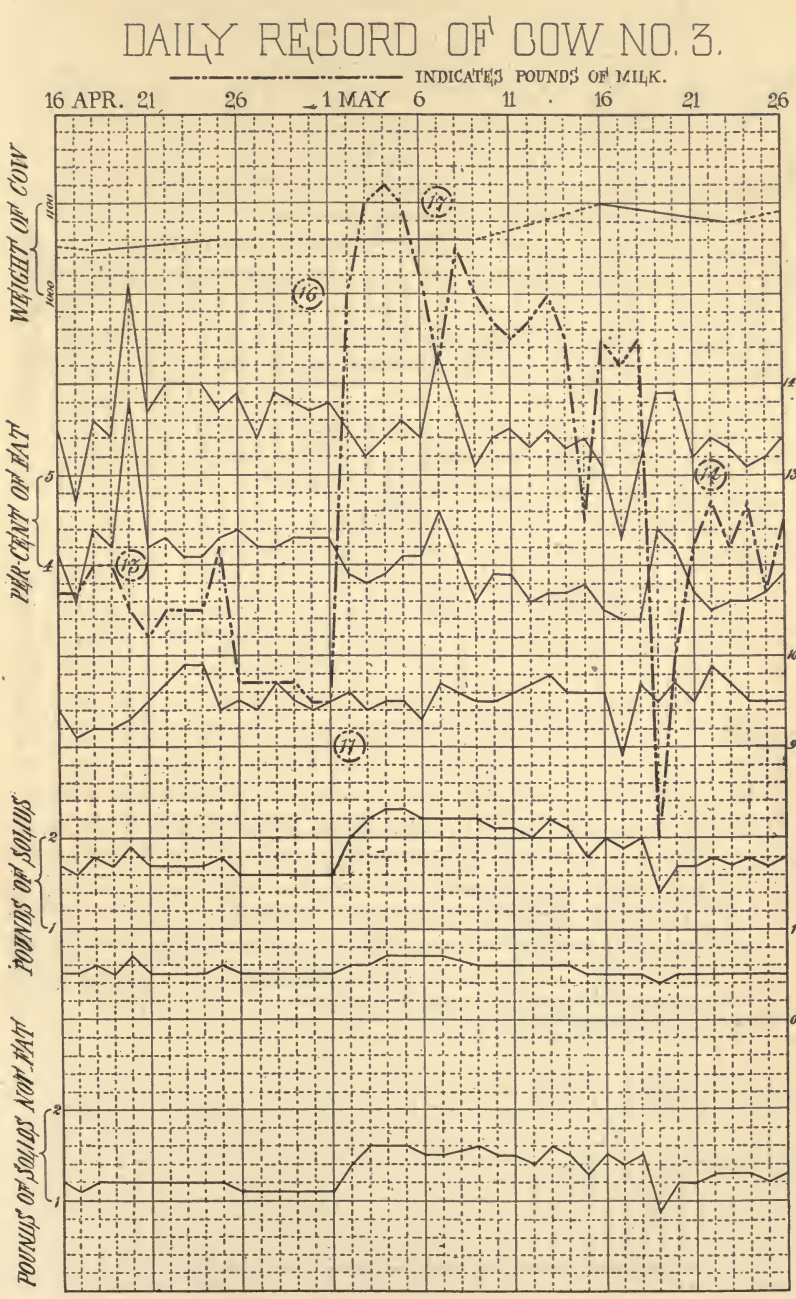
All the striking changes in the composition of the milk produced on any one day are shown by the diagrams to be due to the per cent of fat. This is illustrated by the record of cow No. 1 on Dec. 28th, Jan. 5th and 15th; of No. 5 on Dec. 19th, Jan. 1st and 15th; of No. 3 on Jan. 10th, 23d, April 19th, May 7th, 9th, and 17th to 20th.

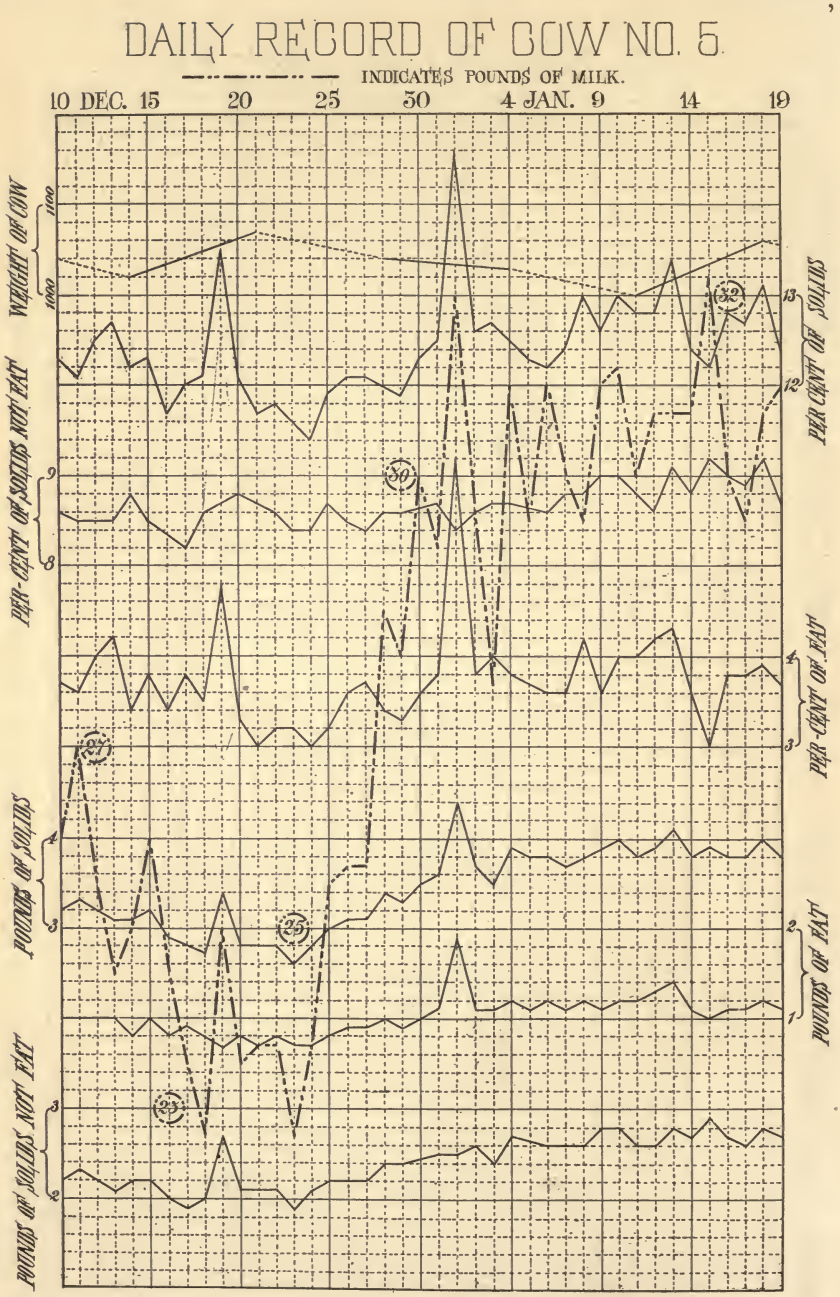
The increase in the daily weight of milk was greatest with cow No. 5. The diagram shows that she gave 22¾ lb. milk Dec. 23d, the quantity increased to 32 lb by Jan. 1st, a gain of nearly 10 lb. per day in a little more than a week.

No. 1 gave 8 lb. more milk Jan. 4th than Dec. 25th. No. 3 increased from 11 lb. Dec. 25th to 17½ Jan. 9th, and when she went from stable to pasture feed she gained in four days nearly 6 lb. milk

DAILY RECORD OF COW NO 1
INDICATES POUNDS OF MILK.
15 DEC. 20 25 30 4 JAN. 9 14 19 24
22
21
20
19
18
17
16
15
14
13
WEIGHT OF COW
600
700
PER CENT OF SOLIDS
PER CENT OF FAT
PER CENT OF SOLIDS NOT FAT
POUNDS OF SOLIDS
POUNDS OF FAT
POUNDS OF SOLIDS NOT FAT


DAILY RECORD OF COW NO 3.
INDICATES POUNDS OF MILK.
18 DEC. 23 28 2 JAN. 7 12 17 22 27
PER-CENT OF FAT
PER-CENT OF SOLIDS NOT FAT
POUNDS OF FAT
POUNDS OF SOLIDS NOT FAT
WEIGHT OF COW
PER-CENT OF SOLIDS
POUNDS OF SOLIDS
(17)
(16)
(15)
(15)
(11)


DAILY RECORD OF COW NO. 3.
INDICATES POUNDS OF MILK.
16 APR. 21 26 1 MAY 6 11 16 21 26
WEIGHT OF COW
PER-CENT OF FAT
POUNDS OF SOLIDS
POUNDS OF SOLIDS NOT FAT
PER-CENT OF SOLIDS
PER-CENT OF SOLIDS NOT FAT
POUNDS OF FAT


DAILY RECORD OF COW NO. 5.
INDICATES POUNDS OF MILK.
10 DEC. 15 20 25 30 4 JAN. 9 14 19
WEIGHT OF COW
1100
1000
PER CENT OF SOLIDS NOT FAT
9
8
POUNDS OF SOLIDS
2
3
POUNDS OF SOLIDS NOT FAT
3
2
PER CENT OF SOLIDS
13
12
PER CENT OF FAT
4
3
POUNDS OF FAT
2
1
(27)
(25)
(23)
(30)
(32)

per day. The diagrams show that these changes in feed stimulated the milk production of the cows so that they each gave from 6 to 10 lb. more milk per day than they had been producing; but the quality of the milk was changed very little. The tables giving the record of each cow for the whole milking period also show that the milk was of the same uniform quality peculiar to the cow in every month, except the last ones when the cows were drying up. The average per cents of solids and of fat in the milk produced each month of the lactation periods do not show so great variations as were observed in some of the different feeding periods, which were considerably less than a month in length.

When the feed was decreased the yield of milk was diminished and the per cent of fat and solids in the milk was somewhat increased for a short time.

When the pasture is abundant the amount of feed eaten is regulated by the cow, and her milk product is probably then controlled by her natural capacity. If the quality of the milk is not changed by different amounts of grain feed from what it is on full pasture feed, it seems safe to assume from this evidence that the per cent of solids and fat in a cow's milk are not greatly influenced in one period of lactation by an increase of feed. The complete records of all these cows show some peculiarities in the milk production that are characteristic of each one and others that are common to all.

There were a few days during the milking periods when the milk was very much richer or thinner than ordinarily, but it soon returned to the quality peculiar to the cow. An inspection of the daily weights and tests made during the whole period of lactation of each of the cows shows that four different combinations of quantity and quality can be found in the milk of some of the cows; more and richer, more and thinner, less and richer, and less and thinner milk than was produced on the day before. Such changes were rare but they show that it is entirely inadmissible to assert that what one cow has done in this way another always can or will do.

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